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Antecedents and consequences of monitoring domestic electricity consumption

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ABSTRACT

Despite evidence that monitoring domestic electricity usage can reduce consumption, there is currently little information on what factors motivate people to monitor their consumption. The present research used an augmented version of the theory of planned behavior as a framework for understanding householders' intentions. Participants ($N = 346$) completed a questionnaire measuring their beliefs about electricity use and monitoring consumption, their environmental behavior, and concern about climate change. Regression revealed that the primary predictors of intentions to monitor consumption were perceived behavioral control, attitudes toward monitoring, past behavior, descriptive, and subjective norms. In addition, we developed a modified home electricity monitor that legged when participants looked at their consumption. A subset of participants ($n = 38$) were given a monitor for three months. Participants looked at the monitor relatively frequently during the first week but usage rapidly declined. There was, however, some evidence that participants found the monitor beneficial.

The UK Government has committed to installing smart meters in all UK homes by 2019 (DECC, 2012) and similar plans exist across the EU and US. It is proposed that one of the key advantages for consumers of having a smart meter will be the accompanying free-standing display that will provide information on electricity use in real time (DECC, 2009); although the UK is relatively unique in mandating the offer of a home energy monitor to every householder who has a smart meter installed. The hope is that providing immediate feedback on electricity use will increase energy literacy and foster changes in behavior that can reduce electricity consumption. Research to date supports this assertion, with a number of large-scale studies suggesting that the provision of electricity monitors can lead to reductions in electricity usage (e.g., AECOM, 2011; Commission for Energy Regulation, 2011), although this effect is dependent on the quality and type of feedback provided (for reviews, see Abrahamse, Steg, Vlek, & Rothengatter, 2005; Burgess & Nye, 2008; Darby, 2006; Faruqui, Sergici, & Sharif, 2010) and may not be sustained over long time periods (e.g., van Dam, Bakker, & van Hal, 2010).[1]

Research has also begun to consider how people use the information obtained from home electricity monitors. For example, Hargreaves, Nye, and Burgess (2010) interviewed 15 householders who had purchased one of three types of electricity monitor. They found that householders preferred to view information on electricity usage in terms of cost, rather than absolute measures of consumption, and that householders used the monitors to identify the costs associated with the use of different electrical appliances. For example, when the monitor indicated that current usage was high, householders reported that they would switch off unused appliances. In addition to studies on domestic electricity monitoring, there is also an extensive literature on how people respond to feedback (e.g., on their performance at work, on lab-based tasks and so on); research that could be used to understand the impact of information about home electricity consumption on householders' thoughts and behaviors. For example, Kluger and DeNisi (1996) reviewed 131 studies and found substantial, but variable, effects of feedback interventions on behavior. The resulting Feedback Intervention Theory (FIT) proposes that feedback serves to change the locus of attention (e.g., from the self as an 'environmentally conscious' person, to actual electricity usage) which, in turn, influences behavior.

There are, however, important questions that need to be addressed before examining how people use the information

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[1] The focus of the present research is on electricity, rather than gas, consumption both for practical reasons (there are currently few commercially available displays for gas usage) and because real-time feedback is more relevant to electricity consumption than to gas (Raw & Ross, 2011).

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obtained from monitoring domestic energy use or respond to feedback – for example, to what extent are people actually motivated to look at the information provided by home electricity monitors? It is currently difficult to find an answer to this question, but Wallenborn, Orsini, and Vanhaverbeke (2011) provide indicative evidence. They report the findings of a survey, which suggests that 69% of Belgians would pay more attention to their electricity consumption if their appliances displayed this information (Wallenborn, Rousseau, & Thollier, 2006). It is also currently unclear how often people actually look at home electricity monitors and what factors influence how motivated people are to monitor their domestic electricity consumption.

These questions are important from both a theoretical and an applied perspective. From a theoretical perspective, frameworks highlight the value of self-monitoring for promoting effective self-regulation and behavior change (e.g., Carver & Scheier, 1982; Ford, 1987; Louro, Pieters, & Zeelenberg, 2007; Miller, Galanter, & Pribram, 1960; Powers, 1973; Powers, Clark, & McFarland, 1960a, 1960b) and empirical studies and reviews support these ideas (see Bravata et al., 2007; de Bruin et al., 2012; Dombrowski, Sniehotta, Avenell, MacLennan, & Araujo-Soares, 2012; Greaves et al., 2011; Harkin et al., 2014; Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Michie et al., 2012). However, we currently understand little about the factors that influence when people are likely (vs. unlikely) to monitor their current standing with respect to their goals. Recent reviews suggest that people may experience difficulties in monitoring, such that, in some circumstances, they are unable or unwilling to do so (Liberman & Dar, 2009; Webb, Chang, & Benn, 2013). From an applied perspective, understanding the factors that influence peoples' motivation to monitor their domestic electricity consumption may help to identify targets for interventions designed to encourage the uptake of domestic electricity monitors and to motivate their use. For example, if motivation is determined primarily by peoples' attitudes toward monitoring electricity consumption, then persuasive communications could be developed that engender positive attitudes toward monitoring.

1. The theory of planned behavior

In the present research, we propose that the decision to monitor domestic electricity consumption is a planned behavior much like the decision to take exercise or to cook dinner. Therefore, monitoring electricity consumption can be understood in terms of frameworks for understanding planned action, such as the theory of planned behavior (TPB; Ajzen, 1991). The TPB suggests that the proximal determinant of a person's behavior is his or her decision about how to behave (or behavioral intention). Intentions are usually measured by endorsement of items such as "I intend to do X!" and indicate the direction and strength of a person's motivation (Ajzen, 1991; Gollwitzer, 1990; Webb & Sheeran, 2005; 2006). According to the TPB, there are three predictors of intention: attitude, subjective norm, and perceived behavioral control. Attitudes reflect the individual's evaluation – positive or negative – of engaging in a particular behavior (Eagly & Chaiken, 1993). For example, Hargreaves et al. (2010) reported that, while some participants believed that monitoring their domestic electricity consumption would be worthwhile and interesting, others were less interested in feedback. Subjective norms refer to beliefs about whether others would approve or disapprove of the person engaging in the focal behavior. Qualitative research by Hargreaves et al. reported that some participants felt that others did not necessarily approve of their monitoring electricity consumption (e.g., "my wife's not that interested in it", p. 6115). Finally, perceived behavioral control is similar to Bandura's (1977) concept of self-efficacy and reflects beliefs about whether one has the necessary resources, abilities, or opportunities to perform the behavior successfully. Thus, although people may have positive attitudes toward monitoring their domestic electricity consumption, and believe that those important to them would approve of their so doing, they may still not intend to monitor their electricity consumption because they believe that this behavior is out of their control. For example, those in shared accommodation (such as student halls of residence) may hold this opinion because they find it difficult to isolate the electricity supply to their accommodation (Kyriakidou, Tucker, Jones, & Webb, 2011).

The TPB has received widespread support as a model of behavior. For example, Armitage and Conner (2001) found that variables specified by the TPB accounted for 27% and 39% of the variance in behavior and intention, respectively. Consistent with predictions, moderate- to large-sized correlations (Cohen, 1992) were found between attitude and intention ($r_+ = 0.49$), subjective norm and intention ($r_+ = 0.34$), and perceived behavioral control and intention ($r_+ = 0.43$). Behavior was significantly predicted by both intention ($r_+ = 0.47$) and perceived behavioral control ($r_+ = 0.37$). The TPB has also been used to understand behaviors relating to the environment, such as the use of public transport (Heath & Gifford, 2002), the consumption of meat (Harland, Staats, & Wilke, 1999), the use of energy saving light bulbs (Harland et al., 1999), switching off lights in the workplace (Greaves, Zibarras, & Stride, 2013), recycling (Cheung, Chan, & Wong, 1999; Nigbur, Lyons, & Uzzell, 2010), intentions to visit an environmentally-friendly hotel (Han, Hsu, & Sheu, 2010), efforts to reduce the environmental impact of organisations (Cordano & Frieze, 2000a, 2000b), and environmental behavior generally (Kaiser, Wolfing, & Fuhrer, 1999). However, to our knowledge, no study to date has investigated whether the TPB can be used to understand the extent to which people monitor their domestic electricity consumption.

2. Augmenting the TPB: anticipated affect, descriptive norms, past behavior, environmental beliefs, and self-identity

Despite the success of the TPB, a number of authors have suggested that the model may usefully be supplemented by additional constructs. First, people may believe that the implications of the information they glean from monitoring may be unpleasant (e.g., higher than expected electricity usage may suggest that one is less environmentally friendly than thought) and so anticipate that monitoring electricity consumption will lead to negative affect (e.g., feelings of worry and guilt, Webb et al., 2013). Anticipated emotions have been shown to be important in determining the choices that people make (Mellers & McGraw, 2001) and measures of, for example, anticipated regret have been shown to predict intentions to exercise (Abraham & Sheeran, 2004) or play the lottery (Sheeran & Orbell, 1999) over and above the cognitions specified by the TPB (for a review, see Sandberg & Conner, 2008). We therefore measured whether participants anticipated that they would feel bad as a result of monitoring their domestic electricity usage.

Research has also pointed to the importance of supplementing subjective norms with descriptive norms that refer, not to perceptions of what others *think* one should do, but to perceptions of what others *actually* do (Cialdini, Kallgren, & Reno, 1991). For example, in a study of intentions to purchase lottery tickets, Sheeran and Orbell (1999) found that descriptive norms influenced intentions over and above attitude, subjective norm, and perceived behavioral control. Furthermore, a meta-analysis of 21 studies measuring descriptive norms revealed a medium-to-large-sized sample-weighted average correlation between descriptive norms and intentions ($r_+ = 0.44$, Rivis & Sheeran, 2003). It therefore seemed important to measure descriptive norms as well as

subjective norms as determinants of the decision to monitor domestic electricity consumption.

The TPB suggests that all influences on behavior are mediated by attitude, subjective norms, perceived behavioral control, and intention (this is known as the 'sufficiency assumption', Ajzen, 1991; Loken, 1983). However, researchers often find that a measure of past behavior has an independent influence on future behavior (for reviews, see Conner & Armitage, 1998; Ouellette & Wood, 1998). Therefore, Ajzen (2002) suggests that researchers should include a measure of past behavior in order to improve the prediction of future behavior. However, Ajzen also makes clear that past behavior lacks explanatory value. That is, knowing that someone did not monitor their domestic electricity consumption last year does not explain why they are not motivated to do so in the following year.

Finally, motivation to monitor domestic electricity consumption may be influenced by more distal variables such as beliefs about the environment (e.g., ecological worldview and environmental concern) and pro-environmental identity (the extent to which people believe that acting in a pro-environmental way is part of their self-identity). As noted above, the sufficiency assumption of the TPB suggests that these variables should not predict additional variance over and above constructs specified by the TPB. However, there is evidence that pro-environmental values can influence intentions (e.g., to donate to an environmental organization, de Groot & Steg, 2007) and measures of self-identity have been shown to predict intentions over and above constructs specified by the TPB in related domains (e.g., recycling, Terry, Hogg, & White, 1999, and the consumption of organically produced vegetables, Sparks & Shepherd, 1992). It therefore seemed prudent to consider these constructs as predictors of peoples' motivation to monitor their domestic electricity consumption.

3. How often do people actually look at the information provided by home electricity monitors?

A second aim of the present research was to investigate how often people actually look at the information provided by home electricity monitors. A pilot of in-home displays in Ontario, Canada found that 39% of participants said that they referred to the display at least once a day (Hydro One Networks, 2006). Hargreaves et al. (2010) report that an initial period of intense interest gave way to less frequent, but still repeated and regular usage. However, all of the participants in Hargreaves et al.'s study had opted to purchase an electricity monitor and were "already engaged and interested in learning more about their energy consumption" (p. 6118). On the basis of research into cognitive dissonance (Festinger, 1957) which suggests that people adjust their cognitions so as to be consistent with their behavior (e.g., Festinger & Carlsmith, 1959, for a review see Harmon-Jones, Amodio, & Harmon-Jones, 2009), it seems likely that people who purchase an electricity monitor may be more motivated to engage with the feedback than people who do not pay for the monitor (e.g., they receive an electricity display alongside the installation of a smart meter).

Perhaps more seriously, the evidence to date on how frequently people look at home electricity monitors has tended to rely on self-reported patterns of usage. The use of self-report measures is potentially problematic in this context due to memory or self-presentation biases. Specifically, people may be reluctant to report that they have stopped looking at the monitor, as so doing may be inconsistent with their beliefs (e.g., concern about climate change) or behavior (e.g., having paid money for a monitor, or expended effort to set it up). Looking at a home electricity monitor is also a relatively trivial, rapid behavior that may be quickly forgotten, especially if looking at the monitor becomes habitual. One study that did objectively measure how frequently participants look at an electricity monitor did not observe a decline in the frequency of monitoring over time. Matsukawa (2004) installed an electricity monitor in the homes of residents in Kyusho, Japan. The system recorded how often residents pressed a button to reveal graphs and tables of their electricity usage. Matsukawa found that participants looked at the monitor an average of 8.7 days in the first month ($SD = 17.7$), 9.6 days in the second month ($SD = 19.5$) and 7.0 days in the third month ($SD = 14.9$). However, Matsukawa did not report a more fine-grained analysis of how frequently participants looked at the monitors (e.g., daily or weekly, rather than monthly). The second aim of the present research, therefore, was to develop an objective measure of the frequency with which people look at home electricity monitors.

4. How do people find using a home electricity monitor and does it influence thoughts and behaviors?

The final aim of the present research was to investigate peoples' experience of using home electricity displays to monitor their domestic electricity consumption. Reviews and qualitative evidence suggest that the provision of consumption information is likely to increase energy literacy and promote savings (Abrahamse et al., 2005; Burgess & Nye, 2008; Darby, 2006; Faruqui et al., 2010; Hargreaves et al., 2010; Wallenborn et al., 2011). However, it is currently unclear whether householders are aware of and appreciate these benefits. Although arguably actual changes in energy-literacy and behavior are more important, perceived benefits form the basis of peoples' attitudes and are likely to determine the extent to which people continue to engage with the monitors over time. Therefore, the third aim of the present research is to consider the extent to which people associate using electricity monitors with positive outcomes.

We also wanted to see whether borrowing an electricity monitor was associated with changes in peoples' beliefs about electricity monitoring and environmental issues more broadly. Specifically, beliefs about monitoring (e.g., that receiving information on electricity usage will make one feel guilty) may change once people have experienced using an electricity monitor. Monitoring may also influence beliefs and behaviors relating to the environment. For example, monitoring may draw people's attention to the issue of electricity consumption (Kluger & DeNisi, 1996) and make them more aware of their impact on the environment. There is also evidence that the adoption of one environmental behavior (e.g., monitoring domestic electricity consumption) can 'spillover' and increase the likelihood that people engage in other pro-environmental actions (e.g., recycling, Thøgersen & Ölander, 2003).

Finally, we wanted to examine the extent to which looking at an electricity monitor becomes habitual over time. Habitual behaviors are those that, having been repeated many times, are triggered automatically by the context in which they are performed (Neal, Quinn, & Wood, 2006; Neal, Wood, Labrecque, & Lally, 2012; Wood & Neal, 2007). For example, if someone looks at their electricity monitor every day after breakfast in order to assess the previous day's electricity usage, then finishing breakfast (the context) is likely to trigger the person to look at their monitor (the habitual behavior) without them having to think about it, or necessarily being aware of so doing. Habitual control of behavior is usually considered to be beneficial, not only because the behavior is more likely to be performed (less likely to be forgotten etc.), but also because performance is efficient to the extent that it does not depend on finite self-control resources (Hagger, Wood, Stiff, & Chatzisarantis, 2010; Neal, Wood, & Drollet, 2013). Habits may, therefore, foster more frequent monitoring. However, if monitoring is to be functional and lead to behavior change, then people have to

reflect on the information and its implications. Thus, habitual monitoring may not necessarily be a good thing as it may suggest that people are not reflecting on the information.

5. The present research

Monitoring household electricity consumption has been shown to be an effective way to engender changes in consumption. Furthermore, the roll out of smart meters in domestic homes means that, in the future, people are likely to have greater opportunities to view their electricity usage in real time. However, it is currently unclear to what extent people will capitalize on these opportunities and what factors will determine engagement. The present research, therefore, sought to answer three questions: (i) What factors predict how motivated people are to monitor their domestic electricity consumption? (ii) How often do people look at home electricity monitors? And (iii) how do people find using an electricity monitor and does usage influence cognitions and behavior toward the environment? To achieve these aims we modified a commercially available home electricity monitor so that it logged when the information was viewed. Participants completed a questionnaire designed to measure the putative determinants of monitoring and a subset then borrowed the modified monitor for a period of 3 months. Upon returning the monitor, participants completed a questionnaire to assess their experiences of using the monitor and current beliefs about monitoring and the environment.

6. Method

6.1. Participants

In October 2012, $N = 346$ staff and students at the University of Sheffield (a large university in the north of England) completed an online questionnaire about monitoring electricity consumption at home. Participants were aged between 18 and 77 ($M = 32.46$, $SD = 12.62$) and 67% were female. Participants tended to be highly educated, with 73% indicating that they held an undergraduate or postgraduate degree. Income ranged from under £10,000 (33% of the sample) to over £50,000 (5% of the sample); although most participants (75%) indicated that they earned less than £30,000 a year.

6.2. Procedure: baseline questionnaire

Attitudes toward monitoring were measured with the stem "Monitoring my household electricity consumption over the next three months would be …" followed by 7-point response scales anchored by: boring – fun, pointless – worthwhile, useless – useful, foolish – wise, unpleasant – pleasant, and satisfying – dissatisfying. Items were reliable ($\alpha = 0.86$) and were averaged.

Subjective norms toward monitoring were measured with three items: "People who are important to me would approve of me monitoring my household electricity consumption over the next three months", "People whose views I value would disapprove if I was to monitor my household electricity consumption over the next three months" (recoded), and "People who are important to me would be disappointed if I didn't monitor my household electricity consumption over the next three months". The scale did not prove reliable ($\alpha = 0.38$) and so the first item was used as an index of subjective norm as it most closely approximates the wording typically used in studies using the TPB (Conner & Sparks, 2005).

Perceived behavioral control over monitoring was measured with three items: "For me to monitor my household electricity consumption over the next three months will be …" (7-point scale: Very easy – very difficult), "I am confident that I can regularly monitor my household electricity consumption over the next three months" (7-point scale: Strongly agree – strongly disagree), and "How much control do you have over whether you monitor your household electricity consumption over the next three months? (7-point scale: No control – complete control) ($\alpha = 0.77$).

Intentions to monitor were measured with three items: "I intend to/am likely to/will try to monitor my electricity consumption over the next three months" ($\alpha = 0.92$).

Descriptive norms toward monitoring were measured with three items: "Of the people that you know best, how many of them monitor their electricity consumption?" (7-point scale: All – none), "Most of my family/friends regularly monitor their electricity consumption (7-point scale: Strongly disagree – strongly agree) ($\alpha = 0.81$).

Anticipated negative emotions were measured with three items: "Knowing how much electricity my household uses over the next three months would make me feel … guilty/regret/upset" ($\alpha = 0.81$).

Past monitoring behavior was measured with four items developed by Webb, Benn, and Chang (2014): "I monitor how much electricity I use at home", "I look carefully at my gas and electricity bills", "I consider whether the amount of electricity that I use at home is increasing or decreasing", and "I do not think about how much gas I use at home" (recoded) ($\alpha = 0.68$).

Ecological worldview (i.e., the belief that human-beings are part of nature rather than separate from it) was measured using the Revised New Ecological Paradigm (NEP; Dunlap, Van Liere, Mertig, & Jones, 2000). The NEP asks participants to respond to 15 statements relating to human–environment interactions (e.g., "We are approaching the limit of the number of people the earth can support") on a 5-point scale anchored by 'strongly disagree' and 'strongly agree'. Responses were summed with higher scores equating to a more ecological worldview ($\alpha = 0.82$).

Environmental behavior was measured with 7 items from the environmental behavior index (Nooney, Woodrum, Hoban, & Clifford, 2003). Participants were asked to indicate whether, over the past two years, they had: (i) contributed time or money to an environmental or wildlife conservation group, (ii) started buying a product because they think it protects the environment, (iii) contacted a government agency to get information about the environment, (iv) read a conservation or environmental magazine, (v) watched a television special on the environment, (vi) voted for or against a political candidate because of his or her position on the environment, and (vii) recycled newspapers, glass, or other items on a regular basis. Items were summed to create a measure of pro-environmental behavior.

Pro-environmental identity was measured with four items from Whitmarsh and O'Neill (2010) who, in turn, had adapted them from Cook, Kerr, and Moore (2002) and Sparks and Shepherd (1992): "I think of myself as someone who is very concerned with environmental issues", "I think of myself as an environmentally friendly consumer", "I would not want my family or friends to think of me as someone who is concerned about environmental issues", and "I would be embarrassed to be seen as having an environmentally friendly lifestyle" ($\alpha = 0.65$).

Concern about climate change was measured with a single item: "How concerned are you about climate change?" (not at all concerned – very concerned).

At the end of the questionnaire, participants were asked whether they would be willing to borrow an electricity monitor for three months. Participants were told that "home electricity monitors are small boxes with a screen that can display electricity use data including graphs and figures describing consumption and costs over time. They work by simply placing a small clip around the main wire bringing the electricity into the home and will then

Fig. 1. Standard (on left) and Modified (on right) 'Classic' Electricity Monitor from Current Cost. It is worth noting that the electricity monitor used in the research is now outdated in terms of design and affordances, with many monitors now able to provide information on the electricity usage of individual appliances (e.g., the ENVI monitor made by Current Cost) and other utilities (e.g., the EnviR monitor made by Current Cost), along with improved feedback on consumption (e.g., traffic light systems such as that employed by the energy monitor made by Ewgeco), and even the ability to control an activation state of appliances (e.g., Patent No. GB2494514-A, 2013). It should also be noted that monitors connected to a smart meter tend to have more sophisticated functions and have been found to be more likely than clip-on monitors (such as that used here) to be fitted, retained, used and rated positively (AECOM, 2011).

send a reading to the display." Participants were asked to supply their email address if they were interested in receiving a free home electricity monitor.

6.3. Procedure: domestic electricity monitoring

Eighty-six (25%) of the respondents indicated that they would be willing to borrow an electricity monitor. These participants were contacted and 38 (44%) were given a 'classic' electricity monitor made by Current Cost (see Fig. 1).[2,3] The monitor provides information on current and past (last week) electricity usage on a 7 cm × 9 cm monochrome LCD display. The monitor was encased in a plastic box with a front flap (see Fig. 1). A small programmable pre-assembled microcomputer (Arduino) was fitted inside the box with a Secure Digital (SD) shield fitted with a 2 GB SD card. When the flap was opened, custom software written for the Arduino microcomputer wrote the time and date to a text file on the SD card. This was done by designing the circuit so that when the flap was opened, an electric circuit was closed, triggering an 'on state' that, in turn, triggered the program execution. We counted discrete flap-openings as those that occurred at least 1 min apart.

6.4. Procedure: follow-up questionnaire

When participants returned the electricity monitor at the end of the three month period they were asked to complete a short questionnaire designed to measure the extent to which they had experienced positive outcomes as a result of monitoring, the extent to which looking at the electricity monitor had become habitual, cognitions pertaining to monitoring domestic electricity consumption in the future, and environmental beliefs.

The extent to which participants had experienced positive outcomes as a result of monitoring was measured with six items: "Monitoring my household's electricity consumption over the past three months has … helped me to understand more about my electricity use/helped me to reduce my electricity use/saved me money/given me a sense of achievement/made me feel good/made me feel bad". The latter item was recoded and items were averaged to form a scale ($\alpha = 0.76$).

The extent to which looking at the electricity monitor had become habitual was measured using the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003). Participants were given the stem "Looking at my electricity monitor is something … I do frequently/I do automatically/I do without consciously remembering/that makes me feel weird if I do not do it/I do without thinking/that would require effort not to do/that belongs to my (daily, weekly, monthly) routine/that's typically me/I have been doing for a long time/I start doing before I realize I'm doing it/I would find hard not to do/I have no need to think about doing". As before, items were averaged to form a scale ($\alpha = 0.93$).

Finally, using the same items as in the first questionnaire, we measured cognitions pertaining to monitoring domestic electricity consumption in the future – attitudes ($\alpha = 0.83$), subjective norms (single item), intentions to monitor ($\alpha = 0.95$), descriptive norms ($\alpha = 0.63$), and anticipated negative emotions ($\alpha = 0.87$). We also measured environmental behavior (sum of 7 yes/no responses) and

[2] Power analysis (Faul, Erdfelder, Lang, & Buchner, 2007) suggested that 54 participants would be needed to detect a medium-sized effect ($d = 0.50$, Cohen, 1992) of monitoring on cognitions and behavior. However, recruiting this number of participants proved problematic. Although 86 participants indicated that they would be willing to borrow an energy monitor in the initial survey, only 38 of these (44%) responded when contacted again, were still interested in borrowing a monitor (e.g., some participants had bought one themselves in the interim), and were in a position to use a monitor (e.g., could identify and access the electricity supply to their property). Thirty-four of the participants (89%) who borrowed a monitor provided usable data (i.e., managed to install the monitor and completed the follow-up questionnaire). It should be recognized, therefore, that the analyses of the effect of borrowing an electricity monitor on cognitions and behavior are likely to be underpowered and so should be considered exploratory and treated with caution.

[3] As a representativeness check, we compared participants who borrowed an electricity monitor with those who did not on key variables (past behavior, attitudes toward monitoring, subjective norm, PBC, descriptive norms, anticipated affect, ecological worldview, environmental behavior, environmental concern, and pro-environmental identity). The multivariate effect was non-significant, $F(11, 207) = 0.98$, $p = .46$, $\text{eta}^2 = 0.05$. However, inspection of the univariate statistics revealed participants who borrowed an electricity monitor had more positive attitudes toward monitoring ($M = 4.03$, $SD = 0.57$) than participants who did not borrow an electricity monitor ($M = 3.68$, $SD = 0.73$), $F(1, 217) = 6.52$, $p < .05$, $\text{eta}^2 = 0.03$.

cognitions pertaining to the environment – ecological worldview ($\alpha = 0.78$), pro-environmental identity ($\alpha = 0.68$), and concern about climate change (single item).

Participants who borrowed an electricity monitor and completed the final questionnaire received £30 for taking part in the study.

7. Results

7.1. What factors predicted intentions to monitor domestic electricity consumption?

Table 1 presents the descriptive statistics for the study variables at baseline. On average, participants had positive attitudes toward monitoring their domestic electricity consumption ($M = 3.59$, $SD = 0.81$), felt that important others would approve of their so doing ($M = 3.53$, $SD = 0.96$), felt moderately in control of monitoring their electricity consumption ($M = 3.18$, $SD = 1.03$), but were unsure whether others actually did so themselves ($M = 2.48$, $SD = 0.84$) or whether monitoring would make them feel guilty or upset ($M = 2.51$, $SD = 0.82$). Most participants had a relatively ecological worldview, viewing humans as a part of nature rather than separate from nature ($M = 3.61$, $SD = 0.53$), reported being moderately concerned about climate change ($M = 3.61$, $SD = 1.11$), and felt that acting in a pro-environmental fashion was part of their identity ($M = 3.95$, $SD = 0.60$). Participants' had relatively positive intentions to monitor their electricity consumption over the next three months ($M = 3.16$, $SD = 1.10$).

In order to explore which variables predicted how motivated participants were to monitor their domestic electricity consumption, we conducted a hierarchical multiple regression with intentions to monitor domestic electricity consumption as the dependent variable and the putative predictors as independent variables (see Table 2). Missing values were replaced with the mean. Past behavior was entered in Step 1 and explained 33% of the variance in intentions to monitor electricity consumption, $F(1, 344) = 167.24$, $p < .001$. Past behavior was positively related to intentions (beta = 0.57, $p < .001$), suggesting that participants who had monitored their domestic electricity consumption (e.g., looked at gas and electricity bills) in the past were more likely to intend to monitor their electricity consumption in the future. The addition of the TPB variables at Step 2 led to a significant increase in the variance explained in intentions ($R^2_{cha} = 0.24$, $F_{cha}(3, 341) = 63.08$, $p < .001$). Inspection of the individual beta weights revealed that the increase in explained variance was attributable to attitudes (beta = 0.27, $p < .001$), subjective norms (beta = 0.08, $p < .05$), and perceived behavioral control (beta = 0.40, $p < .001$).

Table 2
Hierarchical Linear Regression of Intentions on Past Behavior (Step 1), TPB variables (Step 2), Proposed Extensions to the TPB (Step 3), and Environmental Beliefs and Behavior (Step 4).

Step	Variable entered	Beta	Beta	Beta	Beta
1	Past behavior	0.57***	0.19***	0.17***	0.17***
2	Attitude		0.29***	0.27***	0.27***
	Subjective norm		0.11**	0.08*	0.08*
	PBC		0.40***	0.40***	0.40***
3	Descriptive norm			0.16***	0.15***
	Anticipated affect			0.07*	0.07
4	Environmental behavior				0.03
	Ecological worldview				−0.03
	Environmental concern				0.05
	Pro-environmental identity				−0.07
R^2 change		0.33	0.24	0.03	0.00
F change		167.72***	63.08***	11.38***	0.86
R^2		0.33	0.57	0.59	0.60
Model F		167.72***	111.75***	82.83***	49.96***

Note. *$p < .05$, **$p < .01$, ***$p < .001$.

The addition of the proposed extensions to the TPB at Step 3 further increased the variance explained ($R^2_{cha} = 0.03$, $F_{cha}(2, 339) = 11.38$, $p < .001$). Inspection of the individual beta weights revealed that both descriptive norms (beta = 0.16, $p < .001$) and anticipated negative affect (beta = 0.07, $p < .05$) were positively related to intentions. The addition of measures of general environmental behavior, ecological worldview, environmental concern, and pro-environmental identity at Step 4 did not significantly increase the variance explained in intentions over and above TPB variables and the proposed extensions ($R^2_{cha} = 0.00$, $F_{cha}(4, 335) = 0.86$, $p = 0.49$). In the final regression equation, the variables were able to explain 60% of the variance in intentions, $F(10, 345) = 49.96$, $p < .001$, and attitude, subjective norm, perceived behavioral control, and descriptive norm emerged as significant independent predictors of participants' intentions to monitor their domestic electricity consumption.

7.2. How often did participants look at the home electricity monitor?

On average, participants who borrowed an electricity monitor looked at it 15.97 times over the 90 days ($SD = 13.46$). However, while participants looked at the monitor relatively frequently during the first week ($M = 6.48$, $SD = 5.56$), usage rapidly declined

Table 1
Descriptive statistics and correlations between study variables at baseline ($N = 346$).

Variable	M	SD	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
V1. Attitude toward monitoring	3.59	0.81											
V2. Subjective norm	3.53	0.96	**0.36**										
V3. Descriptive norm	2.48	0.84	**0.26**	**0.24**									
V4. PBC	3.18	1.03	**0.40**	**0.19**	**0.27**								
V5. Anticipated affect	2.51	0.82	0.06	0.09	0.03	−0.20							
V6. Past monitoring behavior	3.52	0.87	**0.49**	**0.17**	**0.32**	**0.56**	**−0.13**						
V7. Environmental behavior	3.90	1.66	**0.30**	**0.24**	**0.22**	**0.17**	0.06	**0.29**					
V8. Ecological worldview	3.61	0.53	**0.21**	**0.26**	0.11	0.05	0.06	**0.21**	**0.40**				
V9. Environmental concern	3.61	1.11	**0.33**	**0.29**	**0.18**	0.11	0.08	**0.29**	**0.47**	**0.65**			
V10. Pro-environmental identity	3.95	0.60	**0.32**	**0.27**	**0.17**	**0.22**	−0.07	**0.31**	**0.46**	**0.47**	**0.55**		
V11. Intention to monitor	3.16	1.10	**0.58**	**0.32**	**0.41**	**0.64**	−0.00	**0.57**	**0.25**	0.12	**0.23**	**0.20**	
V12. Frequency of monitoring	15.97	13.46	−0.03	0.13	−0.07	−0.02	−0.26	−0.03	−0.15	0.02	−0.10	−0.17	0.06

Note. All variables could range from 1 to 5, with the exception of environmental behavior (1–7), willingness to borrow a monitor (dichotomous: 0 = no, 1 = yes), and frequency of monitoring (continuous). Correlations in bold are statistically significant ($p < .05$).

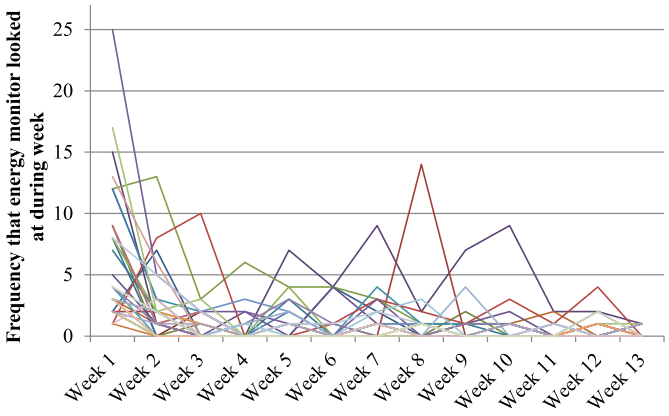

Fig. 2. Frequency that participants looked at the electricity monitor by week.

to an average of 0.79 times a week ($SD = 0.87$) over the following 12 weeks (see Fig. 2). In order to examine the nature of the trend in monitoring frequency over time, we conducted a repeated measures ANOVA with time (week) as the independent variable and frequency of monitoring as the dependent variable. As expected, there was a significant main effect of time, that was best exemplified by a linear trend, $F(1, 32) = 42.76$, $p < .001$, $\text{eta}^2 = 0.57$.[4] In short, participants gradually and predictably looked at the electricity monitor less often over time.

7.3. Beliefs about monitoring electricity consumption, climate change, and behavior at follow-up

Table 3 presents the descriptive statistics for the study variables at follow-up. There was no evidence that looking at the electricity monitor had become a habitual behavior for participants (the mean score on the SRHI was around the midpoint, $M = 2.29$, $SD = 0.79$). However, there was a marginally significant correlation between the extent to which monitoring had become habitual and the frequency with which participants looked at the monitor ($r = 0.33$, $p = 0.07$) suggesting that looking at the monitor had become habitual for those who frequently did so.

Participants experienced positive outcomes from monitoring ($M = 3.71$, $SD = 0.58$). In other words, participants tended to agree that monitoring their domestic electricity consumption over the past three months had helped them to understand more about their electricity use, reduce their electricity usage, save them money, given them a sense of achievement, and made them feel good. The extent to which participants experienced positive outcomes was strongly related to the extent to which looking at the electricity monitor had become habitual ($r = 0.74$, $p < .001$) suggesting that perceiving positive outcomes may have served to reinforce the behavior. Alternatively, people who looked at the monitor frequently may have reported that doing so was beneficial in order to justify their behavior.

In order to examine whether cognitions and behavior differed at follow-up compared to baseline, we conducted nine paired sample *t*-tests, using Bonferroni correction to reduce the likelihood of a Type 1 error (the *p* value was set at 0.006). Only one variable differed significantly between baseline and follow-up: Descriptive norm. Participants were less likely to believe that those close to them monitored their domestic electricity consumption at follow-up ($M = 1.99$, $SD = 0.70$) than at baseline ($M = 2.57$, $SD = 0.69$) ($p < 0.001$). There were trends toward more positive ecological worldview ($p = 0.04$), increases in environmental behavior ($p = 0.03$) and a stronger sense of pro-environmental identity ($p = 0.008$) at follow-up, as compared to baseline, but there were no differences in levels of intention ($p = 0.67$), attitude ($p = 0.41$), subjective norm ($p = 0.57$), anticipated affect ($p = 0.27$), or environmental concern ($p = 0.79$).

8. Discussion

The present research investigated three questions: (i) What factors predict how motivated people are to monitor their domestic electricity consumption? (ii) How often do people look at home electricity monitors? And (iii) how do people feel about using an electricity monitor and does usage influence cognitions and behavior toward the environment? In the discussion, we address each of these questions in turn.

8.1. What factors predict how motivated people are to monitor their domestic electricity consumption?

Participants in the present research had relatively positive intentions to monitor their electricity consumption; a finding that supports Wallenborn et al. (2006; 2011) who reported that the majority of Belgians would pay attention to electricity consumption if their appliances displayed this consumption and evidence from a pilot of real time feedback (Hydro One Networks, 2006) which found that 65% of those surveyed planned to continue to use a monitor after the pilot concluded (Faruqui et al., 2010). However, intentions differed across the sample and were by no means unanimously positive (35% of the sample did not intend to monitor their domestic electricity consumption). The primary predictors of intentions to monitor domestic electricity consumption were past behavior, attitudes toward monitoring, subjective norms, perceived behavioral control, and descriptive norms. In other words, participants were motivated to use a domestic electricity monitor if they had monitored their electricity consumption in some way previously (e.g., by looking at gas or electricity bills), held positive beliefs about monitoring, believed that others around them would approve and are doing so themselves, and that they would be able to monitor their consumption. These findings support the TPB as a model of the factors that influence peoples' motivation to monitor their domestic electricity consumption and add to the substantial evidence base supporting the TPB as a model of planned behavior (for reviews, see Armitage & Conner, 2001; Conner & Sparks, 2005).

Our findings also support proposed extensions to the TPB – both descriptive norms and anticipated emotions influenced intentions to monitor, although the effect of anticipated emotions in the final model was only marginally significant. Like a number of other decisions then (for a review, see Rivis & Sheeran, 2003), intentions to monitor domestic energy consumption are based not only on what others *think* one should do, but also what others *actually* do. Anticipating that monitoring will lead to negative emotions also made it less likely that people would intend to monitor in the future; a finding that may support the idea that there are times when people avoid monitoring in order to protect the self (Webb et al., 2013). Finally, our findings support the sufficiency assumption of the TPB to the extent that more distal predictors such as self-identity, concern about climate change etc. did not predict intentions to monitor over and above variables specified by the TPB. Having said this, we did not measure the impact of structural

[4] Other trends were also significant: quadratic trend, $F(1, 32) = 27.59$, $p < .001$, $\text{eta}^2 = 0.46$, cubic trend, $F(1, 32) = 36.70$, $p < .001$, $\text{eta}^2 = 0.53$, 'order 4', $F(1, 32) = 22.81$, $p < .001$, $\text{eta}^2 = 0.42$, and 'order 5' trends, $F(1, 32) = 6.81$, $p < .05$, $\text{eta}^2 = 0.18$. However, a linear trend provided the best fit to the observed data.

Table 3
Descriptive statistics and correlations between study variables at follow-up ($N = 34$).

Variable	*M*	*SD*	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
V1. Frequency of monitoring	15.97	13.46											
V2. Experienced positive outcomes	3.68	0.56	0.21										
V3. Self-report habit index	2.24	0.75	0.33	**0.72**									
V4. Attitude toward monitoring	3.94	0.50	**0.34**	**0.63**	**0.67**								
V5. Subjective norm	3.65	0.85	−0.13	0.32	**0.34**	0.29							
V6. Intention to monitor	3.56	1.03	−0.02	**0.72**	**0.58**	**0.64**	0.24						
V7. Descriptive norm	1.99	0.70	−0.12	0.27	0.22	0.06	−0.11	**0.40**					
V8. Anticipated affect	2.23	0.90	0.07	0.05	0.23	0.27	−0.19	0.23	0.05				
V9. Environmental behavior	4.44	1.56	−0.15	**0.47**	0.33	0.26	0.19	**0.46**	0.09	0.21			
V10. Ecological worldview	3.79	0.44	−0.05	**0.36**	0.25	0.30	0.02	**0.55**	0.29	0.26	**0.62**		
V11. Environmental concern	3.85	1.13	0.05	**0.45**	0.30	0.30	0.10	**0.35**	0.05	−0.06	**0.57**	**0.57**	
V12. Pro-environmental identity	4.18	0.51	−0.09	**0.39**	0.24	**0.34**	0.23	**0.46**	0.13	0.01	**0.61**	**0.65**	**0.70**

Note. All variables could range from 1 to 5, with the exception of environmental behavior (1–7) and frequency of monitoring (continuous). Correlations in bold are statistically significant ($p < .05$).

factors such as the nature of participants' heating or hot water systems on the likelihood of monitoring.[5] Future research might usefully investigate whether having devices that use a relatively large amount of electricity (e.g., electric space heating, electric showers) increases the likelihood that householders will monitor their consumption and whether the impact of these factors is mediated by cognitions, such as attitudes toward monitoring, as the TPB would predict.

Understanding the determinants of motivation to monitor domestic electricity consumption can help to identify potential targets for interventions designed to promote monitoring. Such interventions are important because evidence suggests that monitoring can improve energy literacy and reduce consumption (for reviews, see Abrahamse et al., 2005; Burgess & Nye, 2008; Darby, 2006; Faruqui et al., 2010). Our findings suggest that interventions should target peoples' attitudes toward monitoring, normative beliefs, and sense of control. The question of how best to do so might be answered using intervention mapping – an approach that seeks to identify the best technique for modifying social cognitive predictors of behavior (Bartholomew, Parcel, & Kok, 1998; Michie, Johnston, Francis, Hardeman, & Eccles, 2008). For example, persuasive communications might be used to target attitudes, while demonstrating the behavior might be used to target normative beliefs. Although a number of reviews point to the efficacy of self-monitoring in shaping behavior change (see Bravata et al., 2007; Dombrowski et al., 2012; Greaves et al., 2011; Harkin et al., under review; Michie et al., 2009; 2012), few studies have identified the factors that influence why people choose to monitor their goal progress (and why they choose not to) and have developed interventions that target these putative determinants in an effort to foster monitoring. As Webb et al. (2013) note "research that can identify why people do not monitor and then target interventions toward these determinants may hold the promise of longer-lasting behavior change" (p. 802). We hope that the present research goes some way toward this aim.

8.2. How often do people look at home electricity monitors?

The present research developed an objective way to measure how frequently people look at a home electricity monitor. The findings indicate that participants looked at the monitor relatively frequently during the first week but that usage rapidly declined over the three months that participants had the monitor such that, by the third week, most participants rarely looked at the monitor. These findings are consistent with research on "the fallback effect" (Wilhite & Ling, 1995), which suggests that the receipt of something new causes people to react, but then that reaction diminishes as the novelty wears off. Likewise, the findings appear to support those of Hargreaves et al. (2010) who also found that an initial period of interest in a home electricity monitor gave way to less frequent usage. However, Hargreaves et al. described this less frequent usage as "still repeated and regular" (p. 6115), whereas in the present research usage declined to an average of just once a week after the first two weeks. Furthermore, there was no evidence that monitoring became habitual for participants in the present research. Our findings appear inconsistent with those of Matsukawa (2004) who found that Japanese residents maintained similar levels of interest in domestic electricity monitors over a three month period. However, Matsukawa only presented frequency information aggregated across monthly periods, potentially obscuring an initial period of high usage.

There are likely to be functional reasons for the declining use of monitors over time. For example, Hargreaves et al. quotes one participant as saying "I probably used it more when we first got it [but then] you develop habits to switch things off and keep the lights off – and then you don't need to look at it so much" (p. 6115). One implication is that householders may not need to be provided with their own displays; rather it would be just as valuable to allow householders to borrow displays for a short period of time, thereby saving on costs. Alternatively, providers may consider loaning monitors on a cycle (e.g., once a year) in order to capitalize on the initial novelty of monitoring.

Our modifications to the home electricity monitor required that we cover the display with a flap that could be lifted to reveal the information. This may have rendered the information less available and salient than if the display had not been covered. For example, unlike a 'normal' home electricity monitor, our modified monitor did not allow the user to glance and quickly determine whether their demand is unusually high or whether they have left an appliance that consumes a lot of energy switched on when they leave the house. Although covering the display may limit direct comparisons with unmodified monitors, this design characteristic may actually render our implementation closer to web or smart phone implementations of electricity use feedback that require the user to log into a website or application in order to view their electricity usage (e.g., Cicirelli, Neri, Nigro, & Pupo, 2013; Peterson, Shunturov, Janda, Platt, & Weinberger, 2007; Weiss, Staake, Mattern & Fleisch, 2011). In these contexts, the information is unlikely to attract the user's attention in the same way that a dedicated real-time display might do, but rather, it requires the user to actively seek it.

[5] We thank an anonymous reviewer for pointing us to the possible importance of structural factors as determinants of monitoring behavior.

There is, however, a potentially important difference between our modified monitor and online systems for monitoring electricity consumption – our monitor was a dedicated device that the householder placed in the home. Unlike a computer that serves multiple functions in a household, the monitor may therefore have served to cue householders to think about – and potentially seek out – information on their electricity consumption. Indeed, previous research asserts that devices need to be placed where they can be seen and used regularly in order to maximize the benefit (Hargreaves et al., 2010). In this sense, our implementation of electricity monitoring falls between a permanently visible, dedicated display and an online or smart phone application. Future research might usefully compare engagement with systems that vary on key dimensions (e.g., physical presence, active vs. passive information provision) within a single study and we hope that the present research provides a framework for this kind of research.

8.3. How do people find using an electricity monitor and does it influence cognitions and behavior toward the environment?

Consistent with objective evidence on the benefits of monitoring domestic electricity consumption (for reviews, see Abrahamse et al., 2005; Burgess & Nye, 2008; Darby, 2006; Faruqui et al., 2010) and survey evidence (e.g., Commission for Energy Regulation, 2011; Hydro One Networks, 2008), participants in the present research reported that monitoring helped them to understand more about their electricity use, reduce their electricity usage, and save them money. They also reported that it gave them a sense of achievement and made them feel good. For the most part, however, participants' cognitions about monitoring (e.g., attitudes, normative beliefs, or intentions) and environmental beliefs and behaviors did not differ after, as compared to before, they borrowed an electricity monitor. These findings are consistent with other research (e.g., the Commission for Energy Regulation reported that energy efficiency interventions that incorporate monitoring did not have secondary benefits in terms of increased awareness of general energy efficiency or subsequent investment) and suggest that monitoring domestic electricity consumption does not increase the likelihood that other pro-environmental behaviors are performed (i.e., does not lead to spillover effects, as described by Thøgersen & Ölander, 2003). It should be noted that there was some evidence to suggest that perceptions of descriptive norm (beliefs about whether important others also monitored their domestic electricity consumption) decreased after borrowing an energy monitor. One interpretation of these findings is that having a monitor led to discussions with others about monitoring, which revealed that others were less likely to monitor than previously thought.

We would, however, exercise two notes of caution in interpreting these findings. First, some of our effects approached significance. For example, there was some evidence to suggest that participants held a more ecological worldview, engaged in more environmental behavior, and had a stronger sense of pro-environmental identity after, as compared to before, borrowing an electricity monitor. Given the relatively small sample, it is likely that our analysis is underpowered (see Footnote 2, for a discussion) and should, therefore, be considered exploratory. Second, the lack of a control group in the present research who did not receive an electricity monitor means that it is difficult to evaluate the effects of borrowing an electricity monitor on cognitions and behavior; that is, our findings cannot account for naturally occurring changes in monitoring or beliefs about the environment over time (e.g., as a result of media reports). We therefore recommend that future research compare cognitions and behavior between participants who receive versus do not receive an electricity monitor using an experimental design.

8.4. Conclusion

Monitoring domestic electricity consumption is currently both necessary to reduce electricity consumption in the domestic sector and, with the advent of smart meters, possible on a large scale. The present research investigated the factors that influence whether people are motivated to monitor their electricity consumption, along with their use of, and experiences with, a home electricity monitor. The findings supported an augmented version of the theory of planned behavior (Ajzen, 1991) to the extent that past behavior, attitudes, normative beliefs, and perceived control influenced intentions to monitor domestic electricity consumption. A novel method for objectively assessing how often participants looked at a home electricity monitor revealed a rapid decline in monitoring over time – a pattern that is intelligible, but may suggest that interventions only need to offer short-term monitoring. Given that participants found monitoring beneficial, finding ways to promote monitoring domestic energy consumption would seem to be a worthwhile aim.

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